**An Introduction to Error Analysis**

Error analysis is the study and evaluation of uncertainty in measurement. Experience has shown that no measurement, however carefully made, can be completely free of uncertainty. In science, we use the term “error” as being interchangeable with “uncertainty.” As such, errors are not mistakes; you cannot avoid them by being very careful. The best you can do is to (a) find reliable estimates of their size and (b) use experimental designs and procedures that keep them as small as possible.

**Reporting experimental results**

When you report a measurement or experimental result in physics, it’s important to always include the uncertainty (as a “plus or minus” amount) as well as the value. For example, when I say that I weigh 150 lbs, I probably don’t mean “exactly 150 lbs” but instead “somewhere in the range of 145 to 155 lbs”, or 150 ± 5 lbs. Of course, if I were paying close attention to my weight, “150 lbs” might mean somewhere between 149 and 150 lbs (150 ± 1 lbs). Or if I say “a newborn moose weighs about 150 lbs”, I might mean somewhere between 100 and 200 lbs (150 ± 50 lbs). We often use significant figures to imply uncertainty. For example, a result of 12.4 Joules is usually interpreted as being between somewhere between 12.3 and 12.5. The general understanding is that the implied “plus or minus” amount is at least the size of the last decimal place. But it’s a much better practice to actually state the uncertainty, such as 12.40 ± 0.05 J or 12.4 ± 0.2 J, rather than let the significant figures “imply” an uncertainty. This way, the reader knows that you have thought about the uncertainty rather than just rounding your result to some arbitrary decimal place. When reporting a value ± uncertainty, the significant figures in the value (and the significant figures in the uncertainty!) should be consistent with the size of the uncertainty. For example, it wouldn’t make much sense to report “12.398318 ± 0.05 Joules”, since the uncertainty makes all of the digits after 9 meaningless. It would also be incorrect to report “12 ± 0.05 Joules”, because here the value is not stated with as much precision as the uncertainty allows. Instead, the result should be written as “12.40 ± 0.05 Joules”. Another silly statement would be “12.398318 ± 0.046252 Joules”, since the uncertainty itself is uncertain! As a general rule, the uncertainty should be rounded to one significant figure, and the value should be rounded to the same decimal place as the uncertainty (or one place more, especially if the first digit of the uncertainty is small). Examples: 112.5 ± 0.5 lbs 124 ± 10 Joules 62,000 ± 5000 km Since the units of the uncertainty must be the same as the units of the value, it is best to write the units at the end, as shown above.